

1 Exploring the relationship between personality and social interactions in zoo-housed elephants:  
2 incorporation of keeper expertise

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4 Ellen Williams\*, Anne Carter, Carol Hall & Samantha Bremner-Harrison

5 School of Animal, Rural and Environmental Sciences, Nottingham Trent University, Brackenhurst

6 Campus, Southwell, Nottinghamshire, NG25 0QF, United Kingdom

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8 \*Corresponding author

9 Email address: [ellen.williams@ntu.ac.uk](mailto:ellen.williams@ntu.ac.uk) (E Williams)

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13 Keywords

14 Zoo elephants, social behaviour, keeper expertise, personality, welfare, social relationships

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27 Abstract

28 Individual animal personalities affect experiences of zoo environments, and thus potentially welfare.  
29 Incorporating keeper knowledge of animal personality in a reliable way has great value in optimising  
30 welfare in zoo-housed animals. Assessment of animal personality has been used to predict group  
31 compatibility and social relationships in a number of species including rhinoceros, gorilla and  
32 chimpanzees, and there is potential to do the same with zoo elephants. This study identified  
33 elephant personalities using keeper ratings, and investigated the relationship between personality  
34 and social interactions in zoo elephants. Behavioural data were collected over a period of 12 months  
35 at seven study facilities (January 2016 – February 2017). Subjects were 10 African (1 male: 9 females)  
36 and 19 Asian (3 male: 16 female) elephants housed at zoos and safari parks in the UK and Ireland.  
37 Each subject was rated using an elephant personality assessment questionnaire, comprising 21  
38 personality adjectives with a visual analogue scale. Personality assessments were completed by 27  
39 keepers. Reliability across keepers was established for nine adjectives and a principal components  
40 analysis revealed three personality components: 'attentiveness', 'sociable' and 'engaged with the  
41 environment'. Correlations were observed between keeper scores of sociability and social  
42 interactions ( $p < 0.05$ ). Elephants considered more sociable by keepers interacted positively with a  
43 greater proportion of elephants in the herd than less sociable elephants ( $p < 0.05$ ). Current Secretary  
44 of States Standards of Modern Zoo Practice (SSSMZP) elephant management guidelines include the  
45 need for long-term management plans, including elephant behavioural profiles and herd  
46 compatibility assessments. The results show that sociability as identified by keepers relates to social  
47 interactions, illustrating the importance of inclusion of personality assessment in management  
48 plans. Future work should build on these findings; applying keeper ratings of elephant personality to  
49 a larger sample size, and exploring potential as a predictive tool in compatibility assessments. Such a  
50 measure would help to increase the chance of successful social group formation contributing to  
51 positive zoo elephant welfare.

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53        **1. Introduction**

54            Personality is defined as ‘individual differences in behaviour that are thought to be stable  
55 across time and situations’ (Powell & Gartner, 2011). Personality is indicative of coping ability  
56 (Gartner & Weiss, 2018), and individual personalities affect how animals perceive and subsequently  
57 experience zoo environments (Hosey *et al.*, 2013; Watters *et al.*, 2017). Catering for individual  
58 personality and understanding group dynamics is important in social and enclosure management, in  
59 order to remove the ‘guesswork’ from management decisions (Gartner & Weiss, 2018) and optimise  
60 welfare of zoo animals (Racevska & Hill, 2017). Zoo animal personality is being increasingly  
61 investigated in a number of species, including chimpanzees (*Pan troglodytes*), black rhinoceros  
62 (*Diceros bicornis*), cheetah (*Acinonyx jubatus*) and giant panda (*Ailuropoda melanoleuca*) (Tetley &  
63 O’Hara, 2012). Keepers can use knowledge of individual personality to identify appropriate roles  
64 within a group for individuals e.g. identifying social compatibility or who to transport to a new  
65 facility (Horback *et al.*, 2014). Personality traits have been used to predict pair or group compatibility  
66 and improve mating success (Carlstead *et al.*, 1999; Fox & Millam, 2014; Martin-Wintle *et al.*, 2017).  
67 Personality traits have also been used to successfully predict friendships in chimpanzees; friendships  
68 were more likely in individuals with similar sociability and boldness scores (Massen & Koski, 2014).

69            Zoo animal personality is most frequently assessed by ‘rating’ behaviour (Tetley & O’Hara,  
70 2012; Watters & Powell, 2012). This method involves human observers (keepers) rating an animal’s  
71 behavioural tendencies along a number of dimensions, based on their experience with the individual  
72 (Highfill *et al.*, 2010). The use of keeper ratings to study personality in zoo animals makes it possible  
73 to measure traits and capture expert knowledge in a standardised and repeatable manner (Gartner  
74 & Weiss, 2018). Keeper ratings have been identified as a reliable and valid means of determining  
75 personality in zoo-housed African and Asian elephants (Grand *et al.*, 2012; Yasui *et al.*, 2013) and in  
76 wild African elephants (Lee & Moss, 2012). Elephant personalities demonstrate temporal stability  
77 (Horback *et al.*, 2013). They have an underlying biological basis (Yasui *et al.*, 2013) and are related to  
78 levels of serum cortisol (Grand *et al.*, 2012). Capturing the knowledge of keepers is extremely

79 important when attempting to identify the needs of zoo animals (Chadwick *et al.*, 2017); keepers  
80 have an intimate knowledge of the individuals they work with and they can integrate knowledge  
81 from a range of situations over a long period of time (Meagher, 2009). In elephants, keepers have  
82 reliably predicted social bonds (when social bonds have been assessed using association data)  
83 (Bonaparte-Saller & Mench, 2018) and play behaviour (Horback *et al.*, 2013).

84 Social group cohesion is one of the most difficult aspects of zoo animal welfare and group  
85 compatibility can play an important part in the success (or failure) of social groups (Williams *et al.*,  
86 2018). Provision of choice in the zoo environment, including choice in social interactions, has been  
87 identified as an important criterion to enhance welfare of social animals (Carlstead & Shepherdson,  
88 1994; Chadwick *et al.*, 2017; Williams *et al.*, 2018). Group compatibility enhances physical safety but  
89 can also create positive affective states (Mellor, 2015) and enhance psychological wellbeing of  
90 individuals (Horback *et al.*, 2014). In zoo elephants, appropriate social groups have been described  
91 as one of the best forms of enrichment (Rees, 2000). Research has revealed individual differences in  
92 tactile interactions in zoo elephants as well as preferences in social partners (Adams & Berg, 1980;  
93 Garai, 1992; Makecha *et al.*, 2012).

94 Assessment of personality for use in pending zoo transfers may have implications for animal  
95 welfare. Researchers have suggested that assessment of personality can be used to increase success  
96 and decrease risks when forming new groups of great apes (Gartner & Weiss, 2018). Being able to  
97 predict potential social compatibility prior to moving individuals would enable zoo keepers to  
98 minimise stress caused to individual animals and increase their long-term welfare. Thus, if keeper  
99 ratings of personality can be used to predict social compatibility in elephants, as has been seen in  
100 other species, it has value in the introduction of individuals into new groups.

101 A link has been established between keeper ratings of social bonds and social association  
102 patterns in elephants in US institutions (Bonaparte-Saller & Mench, 2018). To date no work has  
103 investigated the relationship between personality as rated by keepers and social interactions in UK  
104 and Irish zoo elephants. The aim of this study was to assess individual zoo elephant personalities

105 using keeper ratings and investigate whether there is a relationship between personality and herd  
106 social interactions. It was hypothesised that social interaction frequency would be related to  
107 personality, and that some elephants would be more sociable than others.

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## 109 **2. Methods**

### 110 2.1. Ethics statement

111 All research protocols were approved by the Nottingham Trent University School of Animal, Rural  
112 and Environmental Sciences School Ethics Group. Support for the study was obtained from the BIAZA  
113 Research Group and permission to conduct the study was granted by all of the participating zoos  
114 prior to the commencement of data collection.

### 115 2.2. Subjects and study sites

116 Subjects were 10 African (1 male: 9 females) and 20 Asian (3 male: 17 female) elephants housed at  
117 seven zoos and safari parks in the UK and Ireland (Table 1). Herd size ranged from 2 to 9. An  
118 additional three individuals housed at two of the study zoos (one at Zoo C and two at Zoo E) could  
119 not be included in the data set due to missing data.

### 120 2.3. Data collection

#### 121 2.3.1. Video recording

122 Elephants were identified using visually discernible differences: height, size and shape of  
123 ears, length of tail and presence/absence of hair, scars and tattoos. Data were recorded via live and  
124 video observations. All live observations were conducted from public viewing areas during zoo  
125 visitor hours. Video footage was either provided by the study zoo from existing cameras (Zoo A, C  
126 and E), or cameras were temporarily installed on site (Zoo D, F and G). Where cameras were  
127 installed, video recordings were made of outdoor enclosures using high definition video cameras  
128 with infrared capability (Hikvision IR network camera, Model DS-2CD2632D-IS, Hikvision Europe, The  
129 Netherlands). Cameras had a 20m IR light range and recorded at 20FPS onto bespoke recording kits  
130 designed by Carnyx Wild (Carnyx Wild, UK). To comply with data protection laws no sound

131 recordings were made. A short pilot study was undertaken to determine the most appropriate data  
132 collection methods. The main data collection period ran from January 2016 to February 2017.  
133 Observations were undertaken by a single observer. Data were collected over a five day period with  
134 each day split into 12 x 2-hour periods. Within each 2-hour period data were collected for 1 hour.  
135 Observations were stopped whenever elephants were involved in keeper-initiated interactions (e.g.  
136 public feeding displays or training). There was a discrepancy in the hours of observations which were  
137 able to be undertaken across the study zoos due to external circumstances, e.g. failure of recording  
138 equipment, and it not always being possible to view all study elephants for the full duration of each  
139 observation period due to enclosure set-ups. Data were therefore analysed as a proportion of total  
140 possible observations, to enable comparisons to be made across the study zoos.

#### 141 2.3.2. Social interactions

142 Scan sampling and instantaneous recording with a short inter-scan interval (30 seconds) was  
143 employed to reduce sampling bias, e.g. only recording the first elephant to take part in an  
144 interaction, or to limit introducing an error in interpretation of the context of the interaction. Social  
145 interactions were considered to be positive if they were non-aggressive contact or non-aggressive  
146 approaches (e.g. touching with the trunk), and negative if they were instances of aggression or a  
147 reaction to aggressive behaviour (e.g. walking away from another elephant) (Garai, 1992). Positive  
148 and negative social interactions were then further subdivided into physical and non-physical  
149 interactions (Table 2).

#### 150 2.4. Keeper ratings of elephant personality

151 Elephant personality was assessed using the rating method by keepers familiar with the  
152 elephants. Following consultation with keepers, modifications were made to an existing  
153 questionnaire (Williams *et al.* 2015) to meet study aims. Modifications included removal of terms  
154 which may not be considered to be personality traits (e.g. dominant, subordinate) and inclusion of  
155 extra options for 'towards keepers' and 'towards elephants' for relevant terms (e.g. affectionate,  
156 calm, fearful and play). The final questionnaire comprised 21 adjectives (Table 3). Ratings were made

157 on a 10cm visual analogue scale with the anchors 'disagree' (0cm) and 'strongly agree' (10cm). An  
158 exact score was determined by measuring the distance (in centimetres, to 1dp) along the line that  
159 the rating was placed. Keepers were asked to complete the questionnaires independently of one  
160 another. Rating bias was controlled by including a mix of positive and negative traits within the  
161 questionnaire. Keepers were asked to state how long they had worked with elephants in general and  
162 how long they had worked with the specific herd. Keepers who had worked with elephants or with  
163 the specific herd for less than three months (n=1) were excluded from analysis as the assessment  
164 required knowledge of the individual over time and in a range of contexts.

## 165 2.5. Statistical analysis

### 166 2.5.1. Social behaviour

167 None of the data were normally distributed (Kolmogorov-Smirnov test,  $p < 0.05$ ) therefore all tests  
168 conducted were non-parametric. A Mann-Whitney U test was carried out to investigate the  
169 difference in personality component scores and origin, sex, species and whether individuals were  
170 related to others in the herd. Spearman's rank correlations were undertaken to look at relationships  
171 between the component scores and proportion of individuals in the herd interacted with (positive  
172 and negative) and frequency of interactions (physical and non-physical positive and negative). Data  
173 were also investigated in terms of dyadic interactions, to assess whether elephants were more likely  
174 to spend longer interacting with an elephant to whom they had a similar sociable score. Sociability  
175 was split, based on three equal sections, into low (0 – 3.3), medium (3.4 – 6.6) and high (6.7 – 10)  
176 categories. A Kruskal Wallis test with a Dunn post-hoc test for multiple comparisons was used to  
177 investigate whether there was a difference between sociability scores of givers/receivers in dyads  
178 and frequency of interactions, i.e. whether there was a higher propensity for 'givers' of social  
179 interactions to have higher, lower or equal sociability scores to the 'receivers' of the social  
180 interactions.

### 181 2.5.2. Keeper ratings of elephant personality

182 All data analyses were undertaken in SPSS version 21 (SPSS Inc., Chicago, IL). To determine  
183 inter-rater reliability, intra-class correlation coefficients (ICC (3,k)) were calculated for each  
184 personality adjective (Shrout & Fleiss, 1979). In general, an ICC (3, k) of >0.5 indicates a good level of  
185 agreement between raters (in this instance, keepers); therefore any adjectives with an average ICC  
186 of <0.5 were removed from further analysis. A single score for each personality adjective was  
187 calculated for each elephant by averaging scores across raters. A principal components analysis  
188 (PCA) was conducted to reduce the remaining personality adjectives into components. The  
189 component solution was rotated using varimax rotation and components with eigenvalues >1 were  
190 extracted. Sampling adequacy was assessed by examining the Kaiser-Meyer-Olkin (KMO) statistic  
191 and Bartlett's test of Sphericity. Adjectives with salient loadings (>0.4) on more than one component  
192 were assigned to the component on which it had the higher loading. None of the adjectives loaded  
193 negatively onto the components. Cronbach's alpha was used to detect internal consistency.  
194 Composite scores were calculated as the mean of the adjectives within each component.

195

### 196 **3. Results**

#### 197 3.1. Social interactions

198 Social interactions accounted for a relatively small percentage of total activity (mean±SD, range):  
199 positive physical interactions 2.68±3.18% (0 – 11.54); negative physical interactions 0.04±0.05% (0 –  
200 0.22); positive non-physical interactions 2.21±2.19% (0.03 – 8.4) and negative non-physical  
201 interactions 0.17±0.17% (0 – 0.75).

#### 202 3.2. Keeper ratings of elephant personality

203 Personality assessments were completed by 27 elephant keepers across the seven study zoos for 30  
204 elephants (4 males, 26 females. Elephants were rated by between 3 and 6 keepers (Zoos A, B and F:  
205 4; Zoos C, D and E: 3; Zoo G: 6).

##### 206 3.2.1. Inter-rater reliability and principle components analysis



207 Inter-rater reliability was assessed for 21 personality adjectives. Nine of the 21 adjectives  
208 achieved average ICC values of 0.5 and above (highlighted in bold in Table 4) and were entered into  
209 a PCA. The PCA yielded three components with eigenvalues >1 (Table 5), which accounted for 78.7%  
210 of the total variance. The KMO Measure of Sampling Adequacy was >0.5 and the Bartlett's Test of  
211 Sphericity was <0.001. The three components were named according to the adjectives within them  
212 as 'Attentiveness', 'Sociable' and 'Engaged with the environment'. The loadings of each trait onto  
213 the three components are presented in Table 5. Cronbach's alpha revealed good internal consistency  
214 for each component.

215 Component 1 was labelled 'Attentiveness' and had high positive loadings on the traits  
216 'adaptable', 'calm in novel situations', 'active' and 'inquisitive'. Elephants scoring highly on this  
217 component were considered to be calm and adaptable. Component 2 had high positive loadings on  
218 'sociable', 'affectionate with elephants' and 'playful with conspecifics', and was labelled 'Sociable'.  
219 Elephants who scored highly on this component were considered to be more sociable than  
220 individuals with lower scores, actively seeking interaction with other individuals or engaging in  
221 conspecific play. The final component, component 3, was labelled 'engaged with the environment'.  
222 This component had high loadings for 'affectionate with keepers' and 'playful with objects'. It also  
223 loaded highly for 'inquisitive', however as this personality adjective loaded higher on component 1 it  
224 was assigned to that component for consistency.

### 225 3.3. Component scores

#### 226 3.3.1. Component 1: Attentiveness

227 Male elephants were considered by keepers to be more 'attentive' than female elephants  
228 ( $Z=-2.136$ ,  $p<0.05$ ) however there was no correlation between attentiveness component scores and  
229 any of the other variables (origin, species, relatedness to others or age). There was no correlation  
230 between attentiveness component scores and frequency of social interactions, nor with proportion  
231 of the herd interacted with in either a positive or a negative manner.

#### 232 3.3.2. Component 2: Sociable

233           Elephants considered more 'sociable' by elephant keepers interacted positively with a  
234 greater proportion of elephants in the herd than did less sociable elephants ( $R_s=0.395$ ,  $p<0.05$ ).  
235 There was no correlation between personality and the proportion of the herd interacted with in  
236 terms of negative interactions. Sociable personality component scores decreased as the age of  
237 elephants increased ( $R_s=-0.714$ ,  $p<0.001$ ). There was no correlation between herd size and how  
238 sociable keepers perceived elephants to be. There was also no relationship between the sociable  
239 personality component and the origin of elephants so being born into a zoo was not reflective of  
240 keeper ratings of personality. There was also no relationship between personality and sex, species,  
241 relatedness to others in the herd or between individual elephants. There was a positive correlation  
242 between the sociable personality component score and physical positive interactions ( $R_s=0.627$ ,  
243  $p<0.001$ ) and a negative correlation with the frequency of non-physical negative interactions ( $R_s=-$   
244  $0.505$ ,  $p<0.01$ ). There was no correlation between frequency of negative physical interactions or  
245 non-physical positive interactions and the sociable personality component score.

246           There was a positive correlation between the combined sociable personality component (i.e.  
247 where personality scores of both individuals were combined) and non-physical positive interactions  
248 ( $R_s=0.515$ ,  $p<0.001$ ) indicating that elephants with a higher combined sociable personality score  
249 engaged in a great number of non-physical positive interactions. There was a negative correlation  
250 between the combined sociable personality component score and non-physical negative interactions  
251 ( $R_s=-0.479$ ,  $p<0.001$ ) indicating that the higher the combined sociable personality score for the dyad  
252 (i.e. highly sociable giver and receiver), the fewer non-physical negative interactions were  
253 given/received. Analysis of the sociable personality component scores indicated that for positive  
254 non-physical interactions there was a significant difference between partner types ( $\chi^2=17.461$ ,  $df=4$ ,  
255  $p<0.01$ ). A post hoc test revealed that highly sociable elephants (scoring  $>6.7$ ) engaged in positive  
256 non-physical interactions with other highly sociable elephants more frequently than low scoring  
257 ( $<3.3$ ) elephants engaged with medium scoring (3.4 – 6.6) elephants ( $\chi^2=37.250$ ,  $p<0.05$ ), and  
258 medium scoring elephants engaged with each other ( $\chi^2=-26.635$ ,  $p<0.01$ ). No interactions were

259 recorded for low – low, low – high, medium – low or high – low sociability combinations so these  
260 could not be analysed (Figure 1).

### 261 3.3.3. Component 3: Engaged with the environment

262 Individuals who scored higher on the ‘engaged with the environment’ component interacted  
263 negatively with a greater proportion of the herd than those who scored lower ( $R_s=0.388$ ,  $p<0.05$ ).  
264 There was also a positive correlation between engaged with the environment scores and positive  
265 non-physical interactions ( $R_s=0.385$ ,  $p=0.002$ ). However, there was no correlation between the  
266 ‘engaged with the environment’ component score and frequency of positive physical interactions,  
267 negative physical interactions or negative non-physical interactions. There was no correlation  
268 between the ‘engaged with the environment’ component score and origin, sex, species, relatedness  
269 to others in the herd or age.

270

## 271 4. Discussion

272 The relationship between keeper ratings of elephant personality in UK and Irish herds and  
273 social interactions were investigated. Reliability between keepers reached statistically acceptable  
274 thresholds and three personality factors were identified: ‘engaged with the environment’,  
275 ‘attentiveness’ and ‘sociable’. It was hypothesised that social interaction frequency would be related  
276 to personality, and that some elephants would be more sociable than others. Sociable personality  
277 component scores were not related to elephant origin, sex, species or relatedness to others, but  
278 they decreased as the age of the elephant increased. There was a positive correlation between  
279 combined sociable personality scores in dyads and positive social interactions and a negative  
280 correlation with negative social interactions. Elephants considered to be more sociable by keepers  
281 interacted with a greater proportion of the herd. Elephants considered highly sociable interacted  
282 with other highly sociable elephants more than elephants of other levels of sociability.

### 283 4.1. Personality components and social interactions

284           There was no correlation with the ‘attentiveness’ component. There was a positive  
285 correlation between ‘engaged with the environment’ and positive non-physical interactions,  
286 however elephants who scored higher on that component interacted negatively with a greater  
287 proportion of the herd than those who scored lower. Playfulness and goal-directed behaviours are  
288 considered by the World Association of Zoos and Aquariums (WAZA) to be examples of positive  
289 experiences for animals (Mellor *et al.*, 2015). Elephants that were engaging negatively with a greater  
290 proportion of the herd were considered to be playful (with objects). This is suggestive of positive  
291 welfare states and suggests some level of confidence in the environment. In order for zoo animals to  
292 experience good welfare they must be provided with environments that promote positive affective  
293 states (Mellor, 2016). The results of this study suggest that the welfare of these individuals is not  
294 comprised. The presence of positive social interactions, interaction with the environment and only  
295 low levels of negative social interactions suggest an overall positive affective state for the study  
296 herds.

297           Sociability personality component scores were not related to origin of elephants, sex,  
298 species or relatedness to others in the herd. This suggests that being born into a zoo, or being a  
299 member of a naturalistic herd did not have an impact on the sociability of the study elephants. This  
300 finding is to be expected. Personality is defined as individual differences, stable across time and  
301 situations (Freeman & Gosling, 2010), but it is believed to be shaped by past experiences and  
302 environmental variations (Sachser *et al.*, 2013). Individuals may respond differently to the same  
303 environments but the behavioural changes should change in relation to others in the group (Gosling,  
304 2001).

305           Sociable personality component scores decreased as age increased in the study herds. This  
306 could be linked to development of young animals, settling into their adult personalities as they  
307 mature. The extent to which the zoo environment affects the development of personality is still  
308 unknown. Studies of laboratory rats have found that individual personality can be shaped by early  
309 environments (Rodel & Meyer, 2011). Powell and Gartner (2011) suggest that there is a need to

310 assess the impact of physical and social rearing environments on personality developments, because  
311 there may be the potential to steer personality development. How the zoo environment shapes the  
312 personality of young elephants is an area for future consideration.

#### 313 4.2. Analysis of dyadic relationships

314 There was a positive correlation between combined dyadic scores and non-physical social  
315 interactions and a negative correlation with non-physical negative interactions. It was hypothesised  
316 that there would be a link between levels of sociability of individuals, with individuals who were  
317 highly sociable interacting more frequently with other highly sociable individuals and less frequently  
318 with individuals who were considered less sociable. A relationship between social personality  
319 component scores in dyads was found, but it was not linear. Elephants who scored highly on the  
320 sociable personality component engaged in more positive non-physical interactions with other high  
321 scoring elephants more frequently than low scoring elephants, and medium scoring elephants  
322 engaged most frequently with each other. These differences may be attributable to the relative  
323 hierarchical position of individuals or they may represent a lack of options in terms of sociability  
324 level of herd mates. In the wild, dominance interactions between African elephants were  
325 predominantly dyadic and were most frequent between group matriarchs (Wittemyer *et al.*, 2007).  
326 Research into dolphins has also indicated links between personality and social rank, with the  
327 relationship being most apparent at extremes of the hierarchy (Frick, 2016).

328 Literature on the relationship between personality and social organisation is growing,  
329 particularly in zoo animal welfare studies where it is used to identify potentially more compatible  
330 social groups or appropriate partners for breeding (e.g. Carlstead *et al.*, 1999; Wielebnowski, 1999;  
331 Massen & Koski, 2014; Martin-Wintle *et al.*, 2017). There is still a paucity of literature on the  
332 relationship between personality and social behaviour in zoo elephants, despite recognition of their  
333 complex social relationships and needs. Indeed, for many species the relationship between  
334 personality and social relationships remains largely unclear. Personality and sociability are believed  
335 to be inherently related, with one factor influencing the other. Horback *et al.* (2013) suggested that

336 zoo elephant personalities, as rated by caretakers with an extensive knowledge of the individuals,  
337 could be used as a proxy for long-term behavioural monitoring. A recent study by Bonaparte-Saller  
338 and Mench (2018) was the first to use keeper surveys to assess social bond strength in zoo  
339 elephants, determining that keepers could reliably rate elephant social bond strength and ratings  
340 were related to proximity analyses of the study elephants. However, Bonaparte-Saller and Mench  
341 (2018) found no relationship between keeper ratings of social bond strength and social interactions.  
342 Makecha et al (2012) suggested that personality likely plays a critical role in frequency and types of  
343 social interactions in which elephants engage. Our findings support that assertion; keeper ratings of  
344 personality were related to social interactions in UK and Irish zoo elephant herds. Whilst it was  
345 beyond the scope of this study to assess the use of personality as a predictive tool in assessment of  
346 elephant compatibility, results highlight the potential use of keeper ratings in such an assessment.

347         Elephants are a social species and physical aggression in female wild elephant herds is  
348 minimal (Guthmann, 1970; Lee, 1987; Archie & Chiyo, 2012). Researchers have documented  
349 aggression in zoo elephant herds (Adams & Berg, 1980; Clubb & Mason, 2002; Wilson *et al.*, 2006;  
350 Zoos Forum, 2010) but where details are provided the behaviours observed are those which could  
351 be considered low levels of agonistic interactions, such as displacement (Adams & Berg, 1980;  
352 Wilson *et al.*, 2006). Most reports in wild elephants of physical aggression are from bull elephants,  
353 during musth, a point of heightened sexual activity when elephants have elevated levels of  
354 testosterone (Lincoln & Ratnasooriya, 1996). None of the herds in this study housed more than one  
355 bull elephant. Bulls were housed with females, or with family groups including calves of both sexes.  
356 The minimal aggression observed in this study may also be due to the pro-active management of  
357 social incompatibilities by the study zoos, to prevent escalation of aggression within the herds.

358         Results from this research have the potential for immediate application in industry. Current  
359 Secretary of States Standards of Modern Zoo Practice (SSSMZP) elephant management guidelines  
360 include the requirement for a long-term management plan for individual elephants, including a  
361 behaviour profile which can inform compatibility in the long term collection plan (Defra, 2017). An

362 individual's personality is an important component of a profile and it should therefore be  
363 incorporated into such a document. This study provides evidence for the reliability with which UK  
364 and Irish elephant keepers can rate personality of their animals. Incorporation of keeper ratings of  
365 personality is a simple means of incorporating individual personality into management decisions.  
366 This is not the first-time personality has been advocated for inclusion in welfare assessments, but it  
367 is the first time such a technique has been suggested for inclusion in the long term management  
368 plans of elephant herds and it deserves considerably more thought and discussion moving forward.  
369 Future work should seek to assess the reliability of personality assessment as a predictive social  
370 compatibility tool, for example, when individuals are moved to other herds as part of routine  
371 population management or when group structure changes due to births or deaths.

## 372 **5. Conclusion**

373 The importance of consideration of personality differences has been highlighted in a number  
374 of species both in the wild and zoos. Engagement in positive social interactions is indicative of  
375 positive affective states in zoo animals. The results from this study show that elephants exhibit  
376 unique personalities and that individuals show differing levels of sociability. Recognition of these  
377 differences is extremely important, and using a reliable assessment method which is unambiguous  
378 and repeatable is paramount for inclusion in welfare assessment. Keeper questionnaires were  
379 identified as a reliable means of assessing elephant personality and keeper ratings of personality  
380 were related to frequency of social interactions. Individual differences in zoo animals have  
381 previously been related to: breeding success, resting behaviour and social compatibility. Keepers and  
382 researchers have highlighted the importance of caring for elephants on an individual basis and  
383 recent changes to elephant management guidelines have expressed this sentiment. Current  
384 guidelines state that UK and Irish zoos should provide unique management plans for each animal  
385 and have a long-term management plan for each elephant exhibit (including individual behavioural  
386 profiles and details of herd compatibility). The ability to reliably document personality of zoo  
387 elephants is an important aspect to consider and include in individual management plans. Future

388 work should seek to build on the assessments undertaken here to investigate the potential for  
389 keeper ratings of sociability as a predictive tool in elephant compatibility assessments to optimise  
390 social management of elephants.

391

## 392 **Acknowledgements**

393 The authors would like to extend special thanks to the staff at Belfast Zoo, Blair Drummond Safari  
394 Park, Chester Zoo, Colchester Zoo, Dublin Zoo, Knowsley Safari Park and Twycross Zoo for their  
395 support throughout the project. Thanks to the BIAZA research committee for a letter of research  
396 support, and to members of the BIAZA Elephant Welfare Group (EWG) Behaviour Sub-group for their  
397 input. The project was funded by a VC Scholarship from Nottingham Trent University and a travel  
398 and subsistence grant from Santander.

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515 Table legends

516 Table 1. Elephant and herd demographics for the study elephants at the onset of the study period  
517 (October 2015)

518 Table 2. Elephant behaviour ethogram (based on Asher et al. 2015)

519 Table 3. Adjective and behavioural definitions included in the elephant personality assessment sent  
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521 Table 4. Intra-class correlation coefficient (ICC\*) scores for each personality adjective included in the  
522 keeper assessment of elephant personality. Adjectives with an average ICC value of >0.4 were  
523 entered into a PCA

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525 questionnaire with intra-class correlation coefficient (ICC) scores >0.4

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528 Figure 1. Mean frequency of positive non-physical interactions in relation to the possible personality  
529 combinations. Elephants were grouped according to their level of sociability as reported by keepers  
530 in the elephant personality assessment [Low: 0 – 3.3; Medium: 3.4 – 6.6, High: 6.7 – 10]

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543 Table 1. Elephant and herd demographics for the study elephants at the onset of the study period  
 544 (October 2015)

Zoo	Elephant	Species	Sex	Age	No. relatives in herd	Wild or captive born	If zoo born, at natal zoo?	Observation period (mins)	Proportion observations in sight
A	E1	African	F	45	0	Wild	N/A	5817	0.66
	E2	African	F	47	0	Wild	N/A	5817	0.98
B	E3	Asian	F	54	0	Wild	N/A	5842	0.89
	E4	Asian	F	44	0	Wild	N/A	5842	0.89
	E5	Asian	F	40	0	Wild	N/A	5842	0.85
C	-	Asian	F	49	0	Captive	N	-	-
	E6	Asian	M	15	1	Captive	N	5838	0.16
	E7	Asian	F	1	4	Captive	Y	5838	0.90
	E8	Asian	F	36	3	Wild	N/A	5838	0.78
	E9	Asian	F	19	3	Captive	Y	5838	0.87
	E10	Asian	F	13	3	Captive	Y	5838	0.87
D	E11	African	M	34	0	Wild	N/A	7666	0.20
	E12	African	F	35	0	Wild	N/A	7666	0.27
	E13	African	F	35	0	Wild	N/A	7666	0.67
	E14	African	F	31	0	Wild	N/A	7666	0.69
E	E15	Asian	F	32	8	Captive	N	3267	0.65
	E16	Asian	F	26	8	Captive	N	3267	0.66
	E17	Asian	F	13	8	Captive	N	3267	0.71
	E18	Asian	F	10	8	Captive	Y	3267	0.75
	E19	Asian	M	2	9	Captive	Y	3267	0.61
	E20	Asian	F	2	9	Captive	Y	3267	0.65
	E21	Asian	M	2	9	Captive	Y	3267	0.60
	-	Asian	F	<1	9	Captive	Y	-	-
	-	Asian	M	22	9	Captive	N	-	-
F	E22	African	F	14	1	Captive	Y	5031	0.79
	E23	African	F	30	0	Wild	N/A	5031	0.76
	E24	African	F	14	2	Captive	Y	5031	0.81
	E25	African	F	30	1	Wild	N/A	5031	0.80
G	E26	Asian	F	33	0	Wild	N/A	5016	0.69
	E27	Asian	F	22	1	Captive	N	5016	0.70
	E28	Asian	F	3	1	Captive	Y	5016	0.63
	E29	Asian	F	19	1	Captive	Y	5016	0.68
	E30	Asian	F	34	1	Wild	N/A	5016	0.67

545 *The adult female at Zoo C was removed from the study for consistency between rating data, as her*  
 546 *personality assessment was completed by only two keepers. The calf at Zoo E was not included as it*  
 547 *was born midway through the study. The bull was rated for personality but no corresponding social*  
 548 *behaviour data was available due to video camera quality from outside enclosures so was removed*  
 549 *from the study.*

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553 Table 2. Elephant behaviour ethogram (based on Asher et al. 2015)

<b>Behaviour</b>		<b>Description</b>	
Positive	Positive physical	Conspecific play	Engaging in active play with another elephant, including head-to-head sparring, trunk wrestling, mounting, chasing and rolling on one another. Does not include behaviours observed following an agonistic encounter or courtship.
		Touching (trunk to)	Touching another elephant with the trunk in a non-aggressive manner
		Touching (body to)	Touching/rubbing another elephant with the body
	Positive non-physical	Protecting	Standing over another elephant
		Huddling	Formation of a tight circle with calves at the nucleus. Calves hidden in the middle, adults surrounding them.
		Approach	Walking towards another elephant in a non-threatening manner. Recipient stays in position during and after the approach.
	Negative physical	Approach with trunk	Trunk outstretched towards another elephant. Not close enough to make physical contact.
		Walking with	Walking side by side with another elephant
		Following	Walking closely behind another elephant (within one elephant body length)
		Pushing	One elephant forces or pushes against the body (usually the rump) of another elephant, resulting in the elephant that is being pushed moving at least two steps
Negative	Negative physical	Pulling	Using the trunk to pull at another elephant in a non-playful manner. May pull at the trunk or an accessible body part such as tusks/tushes or the tail.
		Sparring	An escalation of a push/pull incident into more physical aggression
		Hitting/kicking	Aggressive physical contact with the trunk or leg, e.g. trunk strike or kicking out. A largely disciplinary behaviour.
	Negative non-physical	Displace	Movement of one elephant results in another elephant leaving its location (within 10 seconds) - usually occurs when a more dominant elephant approaches a more subordinate individual
		Approach	Walking towards another elephant in an aggressive or hostile manner (head held high, ears wide or flapping). Receiving elephant may either respond to this by standing as tall as possible, head raised, ears flapping or turning away from/walking away from the approaching elephant
		Walking/turning away from	Avoiding or shying away from elephants or people; the individual either walks forwards away from or backwards away from a particular elephant or person
		Frozen	Standing still and alert as another elephant approaches

	Charge/mock charge	Move towards another elephant with the head held high, pace usually quickens as individual gets closer to the target elephant. In the case of a mock charge the individual charging stops further away from the target elephant.
	Blocking	Blocking from food source or other resource (e.g. door)

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581 Table 3. Adjective and behavioural definitions included in the elephant personality assessment sent  
 582 to keepers (n= 27) at the study zoos (n=7) to assess the profiles of their elephants (n=30)

Adjective	Definition
Active	Has high motivation to be physically active
Adaptable	Quickly adapts to novel situations
Affectionate (keepers)	Seeks close relationships to keepers
Affectionate (elephants)	Seeks close relationships to elephants (please place two lines if there is a difference for related or un-related elephants)
Aggressive	Causes harm or potential harm to conspecifics, e.g. displays, chases, bites
Apprehensive	Seems anxious; fears or avoids risk
Calm (unfamiliar people)	Reacts to unfamiliar people in a calm and peaceful manner
Calm (novel situations)	Reacts to novel situations in a calm and peaceful manner
Confident	Behaves in a positive, assured manner
Curious	Shows interest in novel objects
Fearful (conspecifics)	Retreats readily from conspecifics
Fearful (disturbances)	Retreats readily from outside disturbances
Inquisitive	Explores new situations and tries to learn new things
Mischievous	Shows a fondness for causing trouble in a playful way, e.g. sand kicking or trunk grabbing
Playful (conspecifics)	Initiates or readily engages in play with conspecifics
Playful (objects)	Readily engages in play with objects
Placid	Reacts to conspecifics in an even, calm way; is not easily disturbed
Restless	Rarely relaxes, always walking or moving around the enclosure
Sociable	seeks companionship of conspecifics
Solitary	Spends time alone
Vigilant	Carefully watches or listens for possible dangers in the surroundings and easily becomes alerted

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597 Table 4. Intra-class correlation coefficient (ICC\*) scores for each personality adjective included in the  
 598 keeper assessment of elephant personality. Adjectives with an average ICC value of >0.4 were  
 599 entered into a PCA

Adjective	ICC* (3, K)							Average Score (1dp)
	Zoo A	Zoo B	Zoo C	Zoo D	Zoo E	Zoo F	Zoo G	
Active	0.95	0.86	0.67	0.96	0.51	0.79	0.73	<b>0.8</b>
Adaptable	0.92	-0.02	0.01	0.72	0.40	0.59	0.57	<b>0.5</b>
Affectionate (keepers)	-0.14	0.55	0.12	0.95	0.74	0.80	0.37	<b>0.5</b>
Affectionate (elephants)	0.95	0.76	0.30	0.69	0.62	0.52	0.40	<b>0.6</b>
Aggressive	0.47	-0.22	0.44	0.02	0.75	0.74	0.94	0.4
Apprehensive	0.96	0.08	-0.11	-0.01	0.42	0.15	-0.08	0.2
Calm (unfamiliar people)	0.18	0.7	-0.22	0.88	-0.30	0.75	-0.06	0.3
Calm (novel situations)	0.77	0.61	0.40	0.93	-0.02	0.47	0.36	<b>0.5</b>
Confident	0.95	0.56	-0.28	0.73	0.45	0.24	0.04	0.4
Curious	0.79	-0.08	0.28	-0.25	0.40	0.79	0.35	0.3
Fearful (conspicifics)	0.99	0.24	0.01	0.23	0.66	0.37	0.76	0.4
Fearful (disturbances)	-0.32	-0.26	-0.29	0.01	0.15	0.26	0.16	0.0
Inquisitive	0.92	0.01	0.58	-0.03	0.50	0.82	0.36	<b>0.5</b>
Mischievous	0.98	0.62	0.03	-0.13	0.21	0.41	0.63	0.4
Playful (conspicifics)	0.59	-0.18	0.69	-0.08	0.86	0.76	0.60	<b>0.5</b>
Playful (objects)	0.75	0.50	0.60	-0.07	0.74	0.55	0.42	<b>0.5</b>
Placid	0.85	0.36	0.08	0.47	0.52	-0.23	0.08	0.3
Restless	-0.18	0.17	0.27	0.28	0.42	-0.08	0.70	0.2
Sociable	0.96	0.71	0.74	0.76	0.08	0.18	0.73	<b>0.6</b>
Solitary	0.77	0.26	0.92	0.08	0.11	0.34	0.52	0.4
Vigilant	0.66	0.22	0.01	0.40	0.60	0.77	0.40	0.4

600 Values in bold indicate personality adjectives which were entered into a PCA  
 601 \*ICC refers to an intra-class correlation coefficient, which is used as a measure of reliability between  
 602 raters

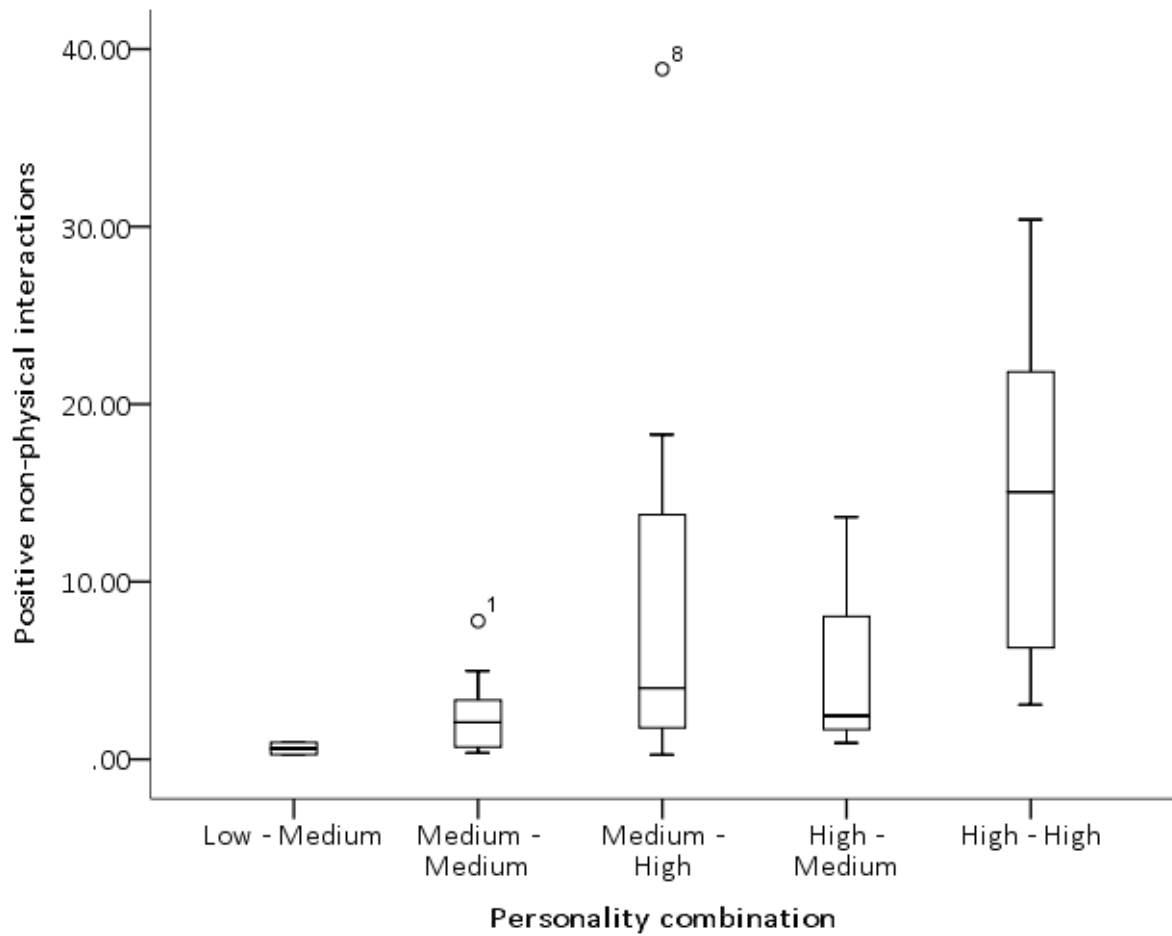
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611 Table 5. Factor loadings and communalities of the 21 personality adjectives in the keeper  
 612 questionnaire with intra-class correlation coefficient (ICC) scores >0.4

Personality adjective	Component 1 (Attentiveness) $\alpha = 0.856$	Component 2 (Sociable) $\alpha = 0.857$	Component 3 (Engaged with the environment) $\alpha = 0.459$	Communality
Adaptable	<b>0.910</b>			0.863
Calm – novel situations	<b>0.873</b>			0.778
Active	<b>0.735</b>	0.431		0.726
Inquisitive	<b>0.578</b>		0.568	0.801
Sociable		<b>0.925</b>		0.865
Affectionate – elephants		<b>0.878</b>		0.802
Playful – conspecifics	0.435	<b>0.697</b>		0.818
Affectionate – keepers			<b>0.838</b>	0.703
Playful - objects		0.447	<b>0.658</b>	0.730
Eigenvalue	4.623	1.387	1.076	
% of variance	51.4	15.4	12%	

613 Loadings of <0.4 are not shown. Factor loadings of less than 0.5 have been omitted. Only adjectives  
 614 whose loadings are highlighted in bold contributed to the formation of the component scores.  
 615 Cronbach’s alpha scores for each component were as follows: component 1 = 0.856, component 2 =  
 616 0.857, component 3 = 0.459.

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633 Figure 1. Mean frequency of positive non-physical interactions in relation to the possible personality  
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 635 in the elephant personality assessment [Low: 0 – 3.3; Medium: 3.4 – 6.6, High: 6.7 – 10]  
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